



***Air Force Studies  
and  
Analyses Agency***



**EFFECTS OF AIR INTERDICTION ATTACKS  
ON  
ADVANCING ARMORED AND MECHANIZED GROUND FORCES**

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## EXECUTIVE SUMMARY

***"Have our better tanks and elite divisions in Normandy been of any avail? No young man, the Americans have got command of the air and they'll keep it. That is a sentence of death for any land army, however large, that has to fight without adequate air cover." Field Marshall Erwin Rommel<sup>1</sup>***

Early attainment of air and maritime superiority by joint forces enables and enhances joint operations in all dimensions. Although not ends in themselves, control of the air and sea have historically been pivotal factors in determining the outcome of combat and contingencies.<sup>2</sup> Control of the air and sea not only shields friendly forces from enemy attacks, but also facilitates effective friendly operations, including interdiction.<sup>3</sup> Interdiction provides a powerful tool for Joint Forces Commanders, as it diverts, disrupts, delays, or destroys the enemy's surface military potential before it can be used effectively against friendly forces.<sup>4</sup> Interdiction can affect enemy capabilities at the strategic, operational, or tactical levels of war.<sup>5</sup> The commanders of air forces, normally the Joint Forces Air Component Commander (JFACC), will most often possess the superior capability to execute interdiction missions.<sup>6</sup>

Therefore, proper representation of air interdiction operations through modeling and simulation is critical for accurate analyses of joint operations. Historically, the impact of air power on mobile forces has been of great importance to the overall campaign outcomes. The most well known historical illustrations of air power influence are from the north African and European theaters in WWII, the 1967 and 1973 Arab-Israeli wars, and Operation DESERT STORM. A review of US Army and Soviet doctrine about air defense reactions illustrates the potential devastation a successful air attack can wreak on undefended ground forces. Even a perfectly executed air defense reaction assures that at a minimum, moving forces are delayed for the duration of the attack. Damage control measures and efforts to regroup and resume movement will result in additional delay. When enough damage occurs to a unit, it loses its capability to perform its assigned combat mission. While estimates vary, units generally lose their combat capability for an offensive mission when suffering 35% attrition of their primary combat entities (tanks, armored fighting vehicles, etc.)<sup>7</sup>.

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<sup>1</sup> B. H. Liddell Hart, The Rommel Papers, Hardcourt, Brace and Company, New York, 1953, p. 498.

<sup>2</sup> Joint Pub 3-0, Doctrine For Joint Operations, Joint Chiefs of Staff, Washington DC, p. IV-5.

<sup>3</sup> Joint Pub 1, Joint Warfare of the Armed Forces of the United States, Joint Chiefs of Staff, Washington DC, 1995, P. IV-11.

<sup>4</sup> Joint Pub 3-0, Doctrine for Joint Operations, p. IV-11.

<sup>5</sup> Test Pub, Joint Pub 3-03, Doctrine For Joint Interdiction Operations, Joint Chiefs of Staff, Washington DC, 1990, p. II-1.

<sup>6</sup> Test Pub, Joint Pub 3-03, Doctrine For Joint Interdiction Operations, p. IV-3.

<sup>7</sup> Yuri Demerenko, Lt Col., Commonwealth of Independent States, interview conducted by Cyrus Holliday, 1993, at Fort Leavenworth, KS.

## DEFINITION

Joint Publication 1-02 defines interdiction as, "An action to divert, disrupt, delay, or destroy the enemy's surface military potential before it can be used effectively against friendly forces."<sup>8</sup> Air interdiction is simply the use of air power to accomplish interdiction at such a distance from friendly forces that integration of each air mission with the fire and movement of friendly forces is not required.<sup>9</sup> This definition of interdiction is still very broad and encompasses a variety of target types. Interdiction efforts target supply stores and distribution systems, command and control facilities, transportation networks and the means to shift engaged troops and move reserve forces.<sup>10</sup> However, this investigation will only deal with direct attacks on moving forces. Air interdiction against mobile ground forces is an asymmetric engagement. In other words, it is an engagement between dissimilar forces. If the attacked ground force is not able to effectively defend against air attacks, then it can be an extremely lethal engagement. Asymmetric attacks can provide a devastating impact that also avoids casualties and saves resources.<sup>11</sup> Of course, interdiction efforts directed against highly mechanized modern forces with intensive logistic requirements produce better results than efforts directed against simple, less mobile forces with minimal logistic requirements.<sup>12</sup>

## INTRODUCTION

Air power provides both "Dominant Maneuver" and "Precision Engagement" capabilities for the Joint Force Commander. In a complimentary fashion, air power also provides a "Full-Dimension Protection" capability to protect our own forces from attack and maintain the initiative.<sup>13</sup> General Dwight D. Eisenhower, supreme allied commander, grasped the unique flexibility of air power. He stated, "Tactically, an air force possesses a mobility which places in the hand of the high command a weapon that may be used on successive days against targets hundreds of miles apart. Aerial bombardments are delivered in such concentrated form as to produce among defending forces a shock that is scarcely obtainable with any amount of artillery."<sup>14</sup> The speed, range and flexibility of air power gives the Air Force an unique "Global Attack" ability -- the ability to attack

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<sup>8</sup> Joint Pub 1-02, Dictionary of Military and Associated Terms, Joint Chiefs of Staff, 1987, p. 187.

<sup>9</sup> Air Force Manual (AFM) 1-1, Volume II, Basic Aerospace Doctrine of the United States Air Force, Department of the Air Force, 1992, p. 271.

<sup>10</sup> Trevor N. Dupuy, Numbers, Predictions, and War: Using History To Evaluate Combat Factors And Predict The Outcome of Battles, The Bobbs-Merrill Company, Inc., Indianapolis and New York, 1979, p. 76.

<sup>11</sup> Joint Pub 1, Joint Warfare of the Armed Forces of the United States, p. IV-10 and 11.

<sup>12</sup> Test Pub, Joint Pub 3-03, Doctrine For Joint Interdiction Operations, Joint Chiefs of Staff, Washington DC, 1990, P. II-1.

<sup>13</sup> John M. Shalikashvili, Chairman of the Joint Chiefs of Staff, Joint Vision 2010, Joint Chiefs of Staff, Washington DC, 1996, pp. 20-23.

<sup>14</sup> Dwight D. Eisenhower, Crusade in Europe, Doubleday & Company, Inc., Garden City New York, 1948, p. 323.

rapidly anywhere on the globe at any time.<sup>15</sup> Air power can compensate for an initial lack of ground combat power that can reach deep.<sup>16</sup> Ground combat operations have the best chance of success when they are synchronized with air superiority and air interdiction.<sup>17</sup> The impact of air power on advancing enemy ground forces, through the combination of attrition and delays, is of tremendous importance to theater commanders. Historically, air attacks have demonstrated the capability to not only delay moving ground forces, but also halt their advance and render them combat ineffective. Therefore, modeling and simulation must accurately portray air power effects to properly analyze various national defense strategies.

Recent studies and wargames corroborate the sensitivity of a ground forces' capability to advance to the effectiveness factor associated with air power strikes. A key to understanding the appropriate factor to assign air power effects for modeling and simulation is to first understand how a ground unit commander determines his units' ability to complete the assigned mission. In the aftermath of an air attack, how does a ground unit commander determine the unit's remaining combat effectiveness? In other words, what is its ability to continue performing its assigned mission following an air attack?

## **HISTORICAL ANALYSIS**

History is replete with accounts of air power directly, and indirectly, impacting the capability of ground forces to move, mass and maneuver. General Dwight D. Eisenhower summarized the decisive influence of air power on the ground battle during WWII. He said, "Our powerful air force ranged far and wide and attacked important targets en masse, almost paralyzing the German power to maneuver and destroying quantities of vital supplies and equipment."<sup>18</sup> A post-WWII study chaired by General Omar N. Bradley investigated the various effects of air power during WWII in Western Europe.<sup>19</sup> Air attacks against trucks, automotive factories, oil production and distribution, and rail transportation were cited for their contributions to ground operations.<sup>20</sup> Tactical attack against road movement was especially cited for its influence on ground operations.<sup>21</sup> Tactical attack was particularly noted for constraining German armored unit

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<sup>15</sup> Sheila E. Widnal, Secretary of the Air Force, and Ronald R. Fogleman, General, USAF, Chief of Staff, Global Engagement: A Vision for the 21<sup>st</sup> Century Air Force, Department of the Air Force, Washington DC, 1996, p. 7.

<sup>16</sup> Field Manual (FM) 100-5, Operations, Headquarters, Department of the Army, Washington DC, 1993, p. 3-10.

<sup>17</sup> Field Manual (FM) 100-7, Decisive Force: The Army In Theater Operations, Headquarters, Department of the Army, Washington DC, 1995, p. 5-1.

<sup>18</sup> Eisenhower, p 9, 261 and 384.

<sup>19</sup> Omar N. Bradley, Effect Of Air Power On Military Operations, Western Europe, United States Strategic Bombing Survey and Air Effects Committee, 12th Army Group, Wiesbaden, Germany, 1945, p. 1.

<sup>20</sup> Bradley, pp. 7-15.

<sup>21</sup> Bradley, p. 178.



movement during the Normandy invasion and the Ardennes offensive (Battle of the Bulge).<sup>22</sup> Tactical attacks confined troop and supply movements to the hours of darkness, which in turn greatly reduced the speed and volume of traffic. Divisions were unable to move, guns could not be repositioned, supplies could not be brought forward, nor could tanks maneuver.<sup>23</sup> General Bradley concluded that "our [allied] air attacks on German motor transportation was one of our most effective offensive measures and paid rich dividends."<sup>24</sup>

However, the US Army did not enter WWII with overwhelming air superiority. During the Tunisian portion of the North African campaign of 1942-43, the US Army had to contend with German air attacks. Constant German air attacks made movement difficult and slow. General Paul Robinett of the 1<sup>st</sup> Armored Division explained the frustration of having to suffer enemy air attacks:

"My regiment has fought well, has had rather severe losses, but can go on. I have talked with all ranks possible and am sure that men cannot stand the mental and physical strain of constant aerial bombing without feeling that all possible is being done to beat back the enemy air effort. News of bombed cities, of ships or ports is not the answer they expect. They know what they see and at present, there is little of our air to be seen."<sup>25</sup>

Several German generals also experienced the effectiveness of air power and agree with General Bradley's assessment. Field Marshal Erwin Rommel was one of the first German generals to feel the dominating impact of allied air power. Rommel's advance through North Africa against the British in 1942 outstripped German fighter coverage. Major General F. W. Von Mellenthin explains that, "Rommel never again enjoyed the advantage of air superiority, and the enemy's air forces grew with terrifying strength. It was the beginning of a process which was to alter the whole balance of the war..."<sup>26</sup> Considering his experience in North Africa, Rommel determined motorized forces were extremely vulnerable to air attack.<sup>27</sup> He further concluded that by fighting a battle of attrition from the air, "The enemy would be in a position to batter our forces so severely as to render them in time virtually unfit for action..."<sup>28</sup> Given his eventual lack of command of the air and inferiority of forces, his successes in North Africa are outstanding achievements.<sup>29</sup> Rommel summarized his experiences with allied air superiority in a letter to the Fuehrer's headquarters.

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<sup>22</sup> Bradley, pp. 162-181.

<sup>23</sup> Bradley, pp. 178-179.

<sup>24</sup> Bradley, pp. 80-81.

<sup>25</sup> Harold T. Gonzales, Jr., Lt Col USAF, Op. Cit., Tactical Air Support of Ground Forces in the Future, Air University Press, Maxwell AFB, May 1990, p. 28.

<sup>26</sup> F. W. Von Mellenthin, Panzer Battles, A Study of the Employment of Armor in the Second World War, University of Oklahoma Press, Publishing Division of the University, 1971, p. 119.

<sup>27</sup> Hart, The Rommel Papers, p. 294.

<sup>28</sup> Hart, The Rommel Papers, pp. 284-285.

<sup>29</sup> B. H. Liddell Hart, The German Generals Talk, William Morrow & Co., New York, 1948, p. 50.

The enemy's command of the air restricts all movement in terms of both space and time, and renders calculation of time impossible. For armored or motorized troops in divisional strength upwards, it limits the possibilities of command and maneuver to night or bad weather operations, which cannot as a rule develop into anything more than operations with limited objective. Daylight action is, however, still possible -- given sufficient A.A. [Anti-Aircraft] defense -- for a small armored combat group.<sup>30</sup>

Rommel's North African exposure to air power subsequently caused him to differ with Field Marshal Von Rundstedt on the deployment strategy required to repulse an allied invasion of France. Rommel believed strong mobile reserves should be positioned forward to check an invasion before it could become established. However, Von Rundstedt, who had not yet experienced air power inflicted constraints on movement, favored a defense in depth.<sup>31</sup> General Heinz Guderian agreed with Von Rundstedt, but, he also recognized the difficulty of moving those mobile forces while pinned beneath allied air supremacy. Later Guderian would write, "Allied air supremacy must in particular affect our ability to move our forces. It seemed likely that in order to achieve sufficient speed and concentration we should have to move only by night."<sup>32</sup> Lieutenant General Fritz Bayerlein's accounts of the Normandy invasion confirm Rommel's appraisal of air power effects. General Bayerlein commanded the Panzer Lehr division during the invasion. He found it nearly impossible to move forward towards Normandy under air attack.

"Every vehicle was covered with tree branches and moved along hedges and the edges of woods. Road junctions were bombed, and a bridge knocked out at Conde. This did not stop my tanks, but it hampered other vehicles. By the end of the day I had lost forty tank trucks carrying fuel, and ninety others. Five of my tanks were knocked out, and eighty-four half-tracks, prime-movers and self-propelled guns. These were serious losses for a division not yet in action."<sup>33</sup>

It is interesting to note that although he reported very few tanks actually destroyed by air attacks, Panzer Lehr Division was nonetheless considerably delayed. In fact, more than 72 hours after the order to move was given, the division still had not arrived.<sup>34</sup> This phenomenon should not be surprising since Petroleum, Oil and Lubricants (POL) are the lifeblood and largest bulk item of modern mechanized forces.<sup>35</sup> Effective attacks on POL re-supply and distribution, therefore, slow rates of advance and curtail mobility and

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<sup>30</sup> Hart, The Rommel Papers, p. 485.

<sup>31</sup> Hart, The German Generals Talk, p.51.

<sup>32</sup> Heinz Guderian, Panzer Leader, Dutton, New York, 1979, p. 328.

<sup>33</sup> Milton Shulman, Defeat In The West, E.P. Dutton & Company, Inc., New York, 1948. p. 107.

<sup>34</sup> Shulman, p. 106.

<sup>35</sup> William Baxter, Soviet AirLand Battle Tactics, Presidio Press, Novato CA, 1986, p. 206.

maneuverability.<sup>36</sup> Air attacks forced the moving vehicles off the open roads. Off-road travel increased fuel consumption rates, while at the same time air strikes destroyed their organic supplies of fuel and the means to distribute it. Attacking a unit's organic supply of POL and means of distribution curtails immediate refueling operations and hampers the ability to distribute what remains to individual vehicles. In the case of advancing combat units, organic supply and means of distribution may be one and the same: military fuel trucks. Higher echelons may eventually be able to re-supply and re-equip attacked units. However, this replenishment will take time and will detract from other efforts. While direct air attack can impede an advancing mobile unit, it may cause even more devastating effects on retreating units which might have to abandon vehicles for lack of refueling capability. The same principles apply to organic supply and distribution of ammunition, food and other supplies, although POL is the most critical item during mobile operations.

Indeed, allied plans placed a great degree of dependence upon the preparatory effort of the air forces against German ground forces, supplies and means of transportation. The destruction of critical junctures on main roads and railroads leading to the Normandy battle area were crucial to the allied battle plan.<sup>37</sup> Other German divisions attempting to move towards Normandy experienced similar difficulties due to air attacks.<sup>38</sup> In contrast, the Third Army's charge out of Cotentin in August of 1944 would later provide an example of the degree of advance possible with a favorable air power advantage. When asked if he worried about his flanks when getting out so far, General George S. Patton, Jr., replied, "No worries. The Air Force takes care of my flanks."<sup>39</sup> Air power provided top cover for local air superiority, close support, and armed reconnaissance out in front of Third Army's advance. Patton's tank crews reported that the only thing slowing them down was the wreckage of German vehicles and artillery that had been knocked out by XIX TAC's fighter-bombers.<sup>40</sup> By September the allied advance had outpaced their capability to transport fuel and ammunition by truck from stockpiles in Normandy, and the advance of Patton's Third Army slowed.<sup>41</sup>

Air power subsequently constrained the movement of German forces during Hitler's last gamble in the Ardennes offensive. The attack was scheduled to begin when flying weather was expected to be at its worst.<sup>42</sup> Indeed, when the forecast bad weather became reality, the allies did suffer the disadvantages the Germans hoped for. General Eisenhower explained, "The air force was one of our greatest assets, and now until the weather improved, it was practically useless. As long as the weather kept our planes on

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<sup>36</sup> Baxter, p. 254.

<sup>37</sup> Eisenhower, pp. 65, 230-231 and 244.

<sup>38</sup> Shulman, pp. 110-115.

<sup>39</sup> H. H. Arnold, General of the Air Force, Global Mission, Harper & Brothers, New York, 1949, p. 543.

<sup>40</sup> Geoffrey Perret, Wing Victory, The Army Air Forces In World War II, Random House, New York, 1993, pp. 312-313.

<sup>41</sup> Carlo D'Este, Patton, A Genius For War, HarperCollins Publishers, New York, 1995, p. 649.

<sup>42</sup> Shulman, pp. 230-235.

the ground it would be an ally of the enemy worth many additional divisions."<sup>43</sup> However, when the bad weather broke, aircraft joined the battle and struck a blow at any lingering hopes of German victory.<sup>44</sup> Evidently, the German experience with allied air attacks also extended to the Eastern Front occasionally. Indeed, on many occasions the Soviets were able to establish local air mastery to their benefit at the important points on the battlefield.<sup>45</sup> Major General Von Mellenthin, describing the first time the Russians enjoyed unquestioned command of the air on July 14, 1944, said, "Eighth Panzer was caught on the move by Russian aircraft and suffered devastating losses. Long columns of tanks and lorries went up in flames, and all hope of a counterattack disappeared."<sup>46</sup>

A subsequent US Army study on the Ardennes offensive concluded the record of achievement by the air was uneven. While some units were unable to move while pinned down by air attacks, other units reportedly had no difficulty moving even in the daylight. The study looked at interdiction attacks against choke points, railyards, bridges, road intersections, and attacks against traffic on the roads.<sup>47</sup> Given the variety of weather conditions encountered, targets struck, aircraft employed, and weapons used, uneven achievement should be expected. The overall impact of air power on the Ardennes offensive was due to many interrelated factors. However, air power attacks against moving vehicles were effective. The report concluded that although armor losses may not have been as great as reported, thin-skinned supply vehicles which lacked tracks for off-road travel presented easy targets.<sup>48</sup> This conclusion agrees with General Bayerlein's account.

Air forces are generally a scarce quantity in relation to the number of potential ground targets they can be employed against. Therefore, air forces are usually concentrated for best effect and not applied "evenly." For example, during the WWII invasion of Salerno, Air Chief Marshal Tedder was directed to concentrate the full strength of his air forces against resolute German formations. This great air attack badly disrupted German communications, supplies, and mobility. The attack regained the initiative for the allies, and was so precise and effective that enemy counterattacks were insufficient to threaten the allies general position.<sup>49</sup> In the present day as well, no effort is usually made to apply air power "evenly," as it is generally still a relatively scarce quantity in relation to the ground forces involved. Efforts are made to apply air power in the manner that best supports the Joint Force Commander's overall scheme. The focused air strikes against the "go-away brigade" during Operation DESERT STORM provides a good example of concentrating air power where it best supports the overall ground scheme of combat. VII Corps commander, General Frederick Franks, determined the

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<sup>43</sup> Eisenhower, p. 345.

<sup>44</sup> Shulman, pp.230-235.

<sup>45</sup> P. H. Vigor, Soviet Blitzkrieg Theory, St. Martin's Press, New York, 1983, pp. 91-92.

<sup>46</sup> Von Mellenthin, p. 285.

<sup>47</sup> Hugh M. Cole, The Ardennes: Battle of the Bulge, United States Army Center for Military History, CMH Publication 7-8, 1965, p. 662.

<sup>48</sup> Cole, p. 661.

<sup>49</sup> Eisenhower, p. 188.

Iraqi 52ND Armored Brigade might have the capability to adversely impact the Corps' eventual advance and so asked targeteers to make it "go away." After intense air attacks, less than 10 percent of its tracked vehicles and 500 troops remained.<sup>50</sup>

The successful use of allied air interdiction also extended to the Pacific theater during WWII. For example, on March 3rd, 1943, American and Australian aircrews bombed and strafed a Japanese convoy of eight destroyers and eight transports carrying half of the their 51st Division to Lae, New Guinea.<sup>51</sup> By 1030 all transports had reportedly been sunk by attacks. Further reports claimed the entire convoy had been sunk, but were exaggerated.<sup>52</sup> Subsequent research into Japanese records shows that all eight transports, four destroyers and 3000 troops were lost. By interdicting the convoy, the Fifth Air Force changed the military balance in New Guinea in the span of one day. The Japanese lost the initiative in New Guinea, and dug in and waited for MacArthur's forces to come to them.<sup>53</sup> In fact, General MacArthur forecast the critical part air power would play in warfare. Years before WWII he reported that the next great war would be one of maneuver and movement and told the secretary of war, "The nation that does not command the air will face deadly odds. Armies and navies to operate successfully must have air cover."<sup>54</sup>

The use of air power for interdiction in other wars and conflicts produced similar results. Without air cover, the North Korean People's Army was vulnerable to attack from the air. For example, on July 10th, 1950, 5th Air Force aircraft discovered and attacked a large convoy of tanks and vehicles in the open. The resulting strikes destroyed a battalion of Korean armor and over 100 trucks, and was described in one official account as "...the greatest destruction of enemy armor of any single action of the war."<sup>55</sup> The Arab-Israeli wars provide good examples of both what is possible with air superiority, and what happens without it. In the 1967 "Six Day War," the Israeli Air Force quickly achieved air supremacy and then engaged in attacking Egyptian ground forces. The destruction at Milta Pass is a testament to the capability of air power to destroy moving ground forces.<sup>56</sup> However, in 1973, the Egyptians were able to deny air supremacy to the Israelis, at least initially. In a reversal from the previous war, Israeli armored forces suffered an initial setback.<sup>57</sup>

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<sup>50</sup> Robert H. Scales, Jr., Certain Victory, The United States Army in the Gulf War, Office of the Chief of Staff, United States Army, Washington DC, 1993, pp. 191-192.

<sup>51</sup> Geoffrey Perret, Old Soldiers Never Die. The Life of Douglas MacArthur, Random House, New York, 1996, p. 333.

<sup>52</sup> Arnold, p. 422.

<sup>53</sup> Perret, Old Soldiers Never Die. The Life of Douglas MacArthur, p. 335.

<sup>54</sup> William Manchester, American Caesar, Douglas MacArthur, 1880-1964, Little, Brown and Company, Boston and Toronto, 1978, p. 158.

<sup>55</sup> Roy E. Appleman, United States Army in the Korean War, South to the Naktong, North to the Yalu, Department of the Army, 1961, p.95.

<sup>56</sup> Trevor N. Dupuy, Elusive Victory, Harper & Row, New York, 1978, p. 246.

<sup>57</sup> Dupuy, Elusive Victory, p. 433.

The capability of air power to dictate ground maneuver was most recently demonstrated during Operation DESERT STORM. The Iraqis resorted to the same movement tactics the Germans used in WWII. They routinely moved vehicles only during hours of limited visibility throughout Operation DESERT STORM. In a little publicized but critical battle, air power caught and targeted Iraqi armored reinforcements on the move. Air attacks stopped and turned back the planned Iraqi follow-on reinforcements, allowing the Coalition to retake the town of Khafji without interrupting the coalition force deployments for the ultimate "Great Wheel" maneuver (referred to as the "Hail Mary" maneuver by General H. Norman Schwarzkopf).<sup>58</sup>

A 1981 Bundeswehr exercise conducted in support of NATO demonstrated German air interdiction theory against second echelon forces. Luftwaffe doctrine for operations against enemy ground forces placed its greatest emphasis on the interdiction of follow-on forces.<sup>59</sup> Delays imposed by air interdiction on the movement of the 4th German Division were measured. Counting all hours of the day, the lead elements averaged about 3.7 kilometers per hour, although they only traveled during darkness. Lead elements reached their operations area, 240 kilometers distant, in 65 hours with an additional 20-25 hours being required for remaining elements. This time is much greater than the German-computed optimum time of 8 hours for their deployment over main roadways, or the non-optimum computed time of 12 hours over minor routes. March columns drew into rest areas during the daytime due to concentrated air attacks. A total of 460 sorties of all types were flown against this division over the course of the exercise. These delays were only caused by the daytime stops and re-routings, as there was no means to account for delays caused by simulated division losses.<sup>60</sup> Although this exercise lacked the actual impact of destruction, casualties, and the fog and friction of real war, it does provide a post-WWII look at air interdiction impacts.

### US ARMY DOCTRINE

Field Manual 100-5, Operations, states, "Air defense operations are key when generating combat power."<sup>61</sup> Air defense provides the force with protection from enemy air attack, and a closer examination of other US Army doctrine and training publications shows why air defense is key. Preparation for combat usually involves the movement of forces across some distance. A "tactical road march" planned at the battalion level and





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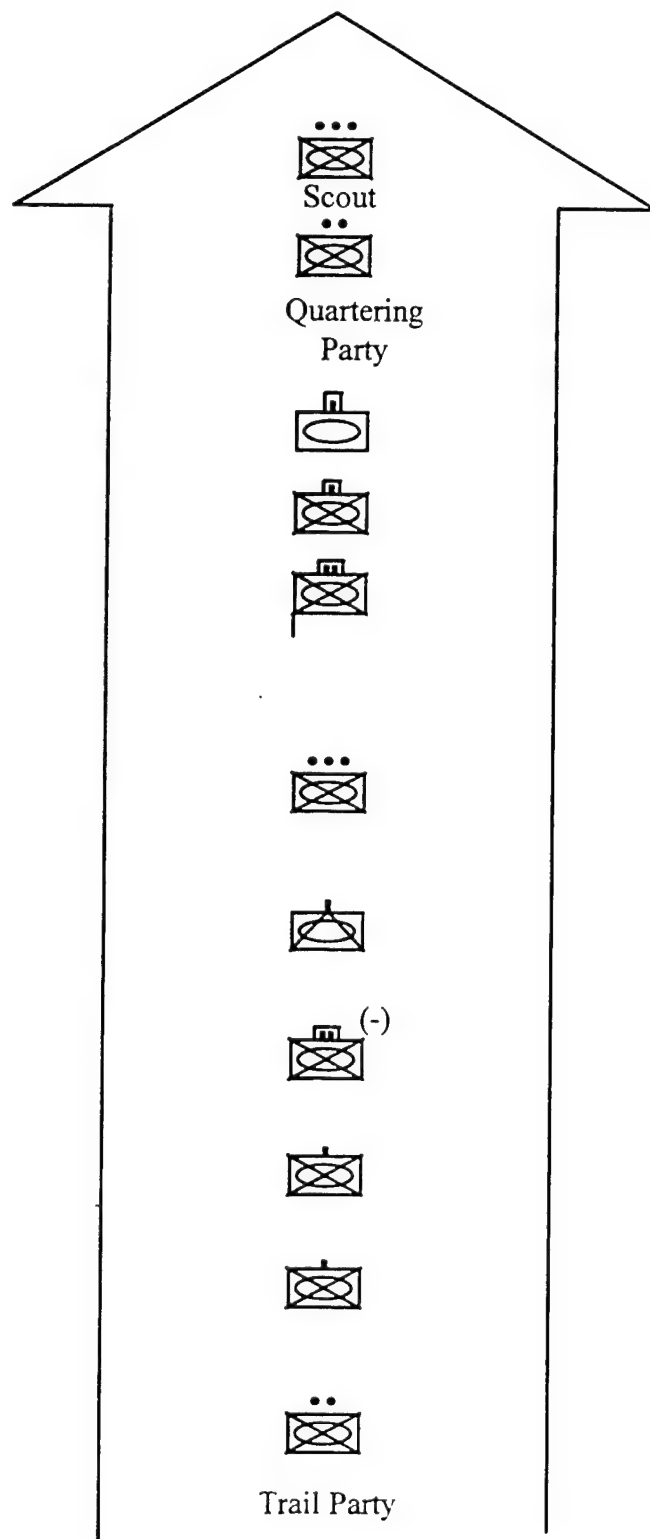
<sup>58</sup> Richard Cheney, Conduct of the Persian Gulf War, Government Printing Office, Washington DC, 1992, pp. 175-176.

<sup>59</sup> Michael E. Thompson, Op. Cit., Political and Military Components of Air Force Doctrine in the Federal Republic of Germany and Their Implications For NATO Defense Policy Analysis, RAND, 1987, p. vi.

<sup>60</sup> Thompson, pp. 99-102.

<sup>61</sup> Field Manual (FM) 100-5, Operations, p. 2-13.

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 Section  
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 Command



**Figure 1: Typical Battalion Task Force Road March Organization<sup>62</sup>**

<sup>62</sup> Field Manual (FM) 71-2, *The Tank And Mechanized Infantry Battalion Task Force*, Headquarters, Department of the Army, Washington DC, 1988, p. C-3.



executed at the platoon level is one means of accomplishing the required movement of forces (see figure 1).<sup>63</sup> Maneuver units, such as tank platoons, cannot always count on receiving dedicated air defense protection.<sup>64</sup> Although US Army units plan to operate with air defense protection, they must depend on their own passive and active air defense measures for close protection and self-defense.<sup>65</sup> Therefore, they must be prepared to protect themselves through measures to avoid enemy air attack, to limit the damage if an air attack does occur, and to fight back if necessary.<sup>66</sup> Avoidance measures include cover and concealment, camouflage, deception, obliteration of vehicle tracks, and the covering of shiny or reflective objects. Damage limiting measures include dispersion, movement to covered and concealed positions, the use of natural and manmade cover, and stopping if the vehicle is in the open. These are passive measures, while active measures include engaging the aircraft with platoon air defense weapon systems, such as tank main guns and machine guns.<sup>67</sup> The Air Defense Artillery (ADA) concept of operations always includes passive measures.<sup>68</sup> In fact, when a Local Air Defense Warning is given for an

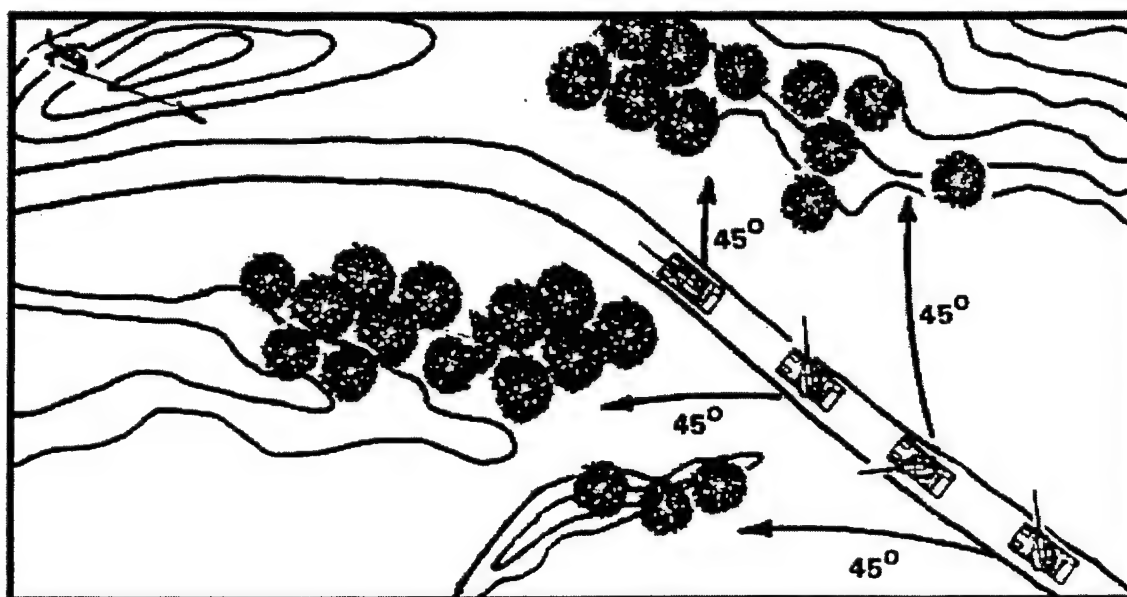


Figure 2: React to Air Attack Drill<sup>69</sup>

<sup>63</sup> All movement is Mission, Enemy, Troops, Terrain and Time (METT-T) dependent. All of these factors are subject to change during the course of a single mission.

<sup>64</sup> Field Manual (FM) 17-15. Tank Platoon, Headquarters, Department of the Army, Washington DC, 1996, p. 6-28.

<sup>65</sup> Field Manual (FM) 44-43. Bradley Fighting Vehicle For Platoon And Squad Operations, Headquarters, Department of the Army, Washington DC, 1995, p. B-1.

<sup>66</sup> Field Manual (FM) 17-15. Tank Platoon, p. 6-28.

<sup>67</sup> Fort Knox Supplemental Material (FKSM) 17-15-3. Tank Platoon Standard Operating Procedures (SOP), US Army Armor Center & School, Fort Knox KY, 1996, pp. 75-76.

<sup>68</sup> Field Manual (FM) 44-100. US Army Air Defense Operations, Headquarters, Department of the Army, Washington DC, 1995, p. 6-15.

<sup>69</sup> Field Manual (FM) 17-18. Light Armor Operations, Headquarters, Department of the Army, Washington DC, 1994, Figure 4-28.



imminent or occurring air attack, air defense systems will attempt to engage the attacking aircraft while other units will cease movement and seek possible cover.<sup>70</sup>

Unless the situation requires immediate active measures, the tank platoon initially takes passive measures. When the platoon is in the direct path of an attacking aircraft, the "react to air attack drill" is initiated. The first step is to initiate fire to force the attacking aircraft to initiate self-defense measures that alter their attack profile. The second step is for the tanks to create a non-linear target by moving as fast as possible at a 45-degree angle away from the path of flight (see figure 2). The third step is for the tanks to take up covered and concealed positions and freeze their movement for at least 60 seconds after the last flight of aircraft has passed.<sup>71</sup> Dedicated Air Defense vehicles may execute a 90 degree turn towards the direction of attack, as a quick way to get out of the line of fire.<sup>72</sup> Stopping appears to be essential whether cover and concealment are available or not. This is because "a stationary vehicle is more difficult to see than a moving vehicle."<sup>73</sup> These same passive and active measures are also employed by scout platoons.<sup>74</sup> Cavalry operations also rely on the same passive and active air defense measures.<sup>75</sup> Bradley mechanized infantry platoons employ both passive and active measures, but with one difference. Vehicles under air attack move off the axis of attack seeking cover and concealment, or they continue moving in an evasive manner.<sup>76</sup> With the exception of measuring distances in meters and moving vehicles off the road instead of abandoning them in place, these reactions are quite similar to those described by General George S. Patton. He explained, "If you see the plane in time, you stop the car and run like hell for 50 yards off the road and lay down. It seems most undignified but all do it."<sup>77</sup>

Battle drills, such as the "react to air attack" drill, may prove critical to preserve lives and protect equipment. They can be carried out under nearly all battlefield conditions, although mission, enemy, troops, terrain and weather, and time available (METT-T) factors may affect the actual execution of the battle drills. Practice makes reactions to specific sets of battlefield cues automatic.<sup>78</sup> Battle drills allow units to

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<sup>70</sup> Field Manual (FM) 71-3, The Armored And Mechanized Infantry Brigade. Headquarters, Department of the Army, Washington DC, 1996, p. H-31.

<sup>71</sup> Field Manual (FM) 17-15, Tank Platoon, p. 3-40.

<sup>72</sup> Field Manual (FM) 44-63, FAAD/SHORAD Battalion Operations, Heavy Division, Headquarters, Department of the Army, Washington DC, 1993, p. C-1.

<sup>73</sup> Field Manual (FM) 17-15, Tank Platoon, p. 6-29.

<sup>74</sup> Field Manual (FM) 17-98, Scout Platoon, Headquarters, Department of the Army, Washington DC, 1994, pp. 7-50 to 7-52.

<sup>75</sup> Field Manual (FM) 17-95, Cavalry Operations. Headquarters, Department of the Army, Washington DC, 1996, pp. 9-34, 35 and C-3.

<sup>76</sup> Field Manual (FM) 7-7J, Mechanized Infantry Platoon and Squad (Bradley), Headquarters, Department of the Army, 1993, p. 4-28.

<sup>77</sup> Martin Blumenson, The Patton Papers, 1940-1945, Houghton Mifflin Company, Boston, 1972, p. 186.

<sup>78</sup> Army Training and Evaluation Program (ARTEP) 17-237-10 Mission Training Plan (MTP) For the Tank Platoon, Headquarters, Department of the Army, 1996, p. A-1.

quickly react during the critical wartime operations conducted to move, attack and defend.<sup>79</sup>

Air defense measures are particularly critical for operations in a desert environment. Field Manual 90-3, Desert Operations explains that, "The desert is an outstanding environment for employing aircraft." Units moving in column and under air attack must move 40 to 50 meters off the road, because a vehicle on the road or on either side of the road will die.<sup>80</sup> Regardless of whether the vehicles stop or continue moving off axis during air attacks, the end result will be eventual delays in resumed movement towards their final destination. Moving large numbers of vehicles towards a common destination in an orderly fashion is a complex task. Successful tactical road marches require careful coordination and control of timing, order of march, rate of march, locations, routes, communications, and other factors.<sup>81</sup> Therefore, some amount of time will be required in the aftermath of an air attack just to reposition and reform before resuming the road march.

It is obvious why either air supremacy or organic unit air defense capabilities are highly desirable. Control of the air is necessary not only to limit or prevent attrition and casualties from enemy air attacks, but also quite necessary to the movement of one's own forces. This was clearly demonstrated throughout Operation DESERT STORM, when air supremacy permitted the Coalition total freedom of movement, while denying movement capability to the Iraqis.<sup>82</sup>

## SOVIET TACTICS

An often expressed view about Russian<sup>83</sup> reaction to air attacks is that their columns will simply speed up and increase spacing between vehicles. This view fits the image of thousands upon thousands of Soviet soldiers charging into German lines during the Great Patriotic War (WWII). Although the Soviets did sacrifice many lives during WWII, they did not do so without cause or purpose. While this simplistic view may be correct for certain circumstances, it is not universally true in today's Russian Army. The Russian Army reacts to attrition in a manner similar to other modern armies.<sup>84</sup> They will take measures to ensure the safety of personnel, and to safeguard weapons systems and

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<sup>79</sup> Army Training and Evaluation Program (ARTEP) 17-237-10 Mission Training Plan (MTP) For the Tank Platoon, p. ii.

<sup>80</sup> Field Manual (FM) 90-3, Desert Operations, Headquarters, Department of the Army, Washington DC, 1993, p. 3-13.

<sup>81</sup> Field Manual (FM) 7-7J, Mechanized Infantry Platoon and Squad (Bradley), p. 4-25 to 4-28.

<sup>82</sup> Les Aspin and William Dickinson, Defense For A New Era, House Armed Services Committee, US Government Printing Office, 1992, p. 7.

<sup>83</sup> The term Russian will be used to discuss current phenomena and the term Soviet will be used for historical discussions.

<sup>84</sup> Trevor N. Dupuy, Attrition. Forecasting Battle Casualties and Equipment Losses in Modern War, Hero Books, Fairfax VA, 1990, p. ix.

other equipment. They will treat or evacuate their wounded, remove damaged vehicles from the road, and perform damage control in the aftermath of air strikes.<sup>85</sup>

If small groups of aircraft attack properly defended tank columns, the Russians may simply speed up and increase spacing while air defense assets engage the attackers, until movement becomes impossible. Lines of advance blocked with wreckage that cannot be skirted, roads damaged with extensive cratering, significant attrition to vehicles or high casualty rates, will force columns to halt and seek cover.<sup>86</sup> Furthermore, Russian doctrine indicates that attacks by large groups of aircraft or the lack of proper air defense coverage requires damage-limiting measures to be taken, such as pulling off the road and seeking cover.<sup>87</sup> The Soviet Army developed a respect for the threat from the sky through their experience with the German Luftwaffe in WWII, and by analyzing the wars in Asia and the Middle East.<sup>88</sup> Since they have provided their forces with an impressive air defense capability, they may believe their columns will only rarely come under undefended air attack. Even so, they are prepared for the event. Perhaps more importantly, many other Russian (or Soviet) style armies are not as impressively protected, and, air defenses can be neutralized through a variety of means. Even Iraq's much touted air defense system quickly succumbed to coalition attacks during Operation DESERT STORM.<sup>89</sup>

History and exercises clearly demonstrate the recognized impact of direct air interdiction attacks against moving ground forces. The impact of air attacks cannot be accurately represented by a mere tally of destroyed and damaged combat vehicles. Evidence suggests that weapons expended against organic unit supply vehicles, particularly POL vehicles, are not merely sortie sinks that soak-up weapons without effecting the tanks, armored vehicles and other primary combat weapon systems they support. Air interdiction attacks whittle away at the primary combat weapon systems of a mobile unit and that unit's organic means to support them and remain mobile. Attacked units are not only delayed while under attack, but also while performing damage control to report, reform, and resume in the aftermath of air attack.

### QUANTIFYING IMPOSED DELAYS

The problem of quantifying and appropriately applying appropriate impacts for use in Modeling and Simulation (M&S) is difficult. It is very important to precisely

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<sup>85</sup> V. G. Reznichenko, *Tactics. A Soviet View*, Published Under the Auspices of the United States Air Force, Taktika Translated by the CIS Multilingual Section, Translation Bureau Secretary of State Department, Ottawa, Canada, 1987, pp. 201-202.

<sup>86</sup> Reznichenko, pp. 202 and 210.

<sup>87</sup> *Soviet Army Operations*, Department of the Army, United States Army Intelligence and Security Command, United States Army Intelligence And Threat Analysis Center, 1978, p. 3-26.

<sup>88</sup> Baxter, p. 148-149.

<sup>89</sup> *The 100 Hour Ground War: How the Iraqi Plan Failed*, United States Army, G2, VII Corps, 1994, pp. 60-62.

specify the problem and conditions to be quantified. The task is to express, under a variety of conditions, the delays imposed upon advancing armored and mechanized units through air interdiction. Air imposed delays caused by direct attacks can be grouped into three categories: immediate, aftermath, and residual. First, the attacked units are immediately delayed from the time they realize they are under air attack and take appropriate actions, until they determine the attack is over. Second, the units are delayed in the aftermath while assessing damage, reporting, treating casualties, repairing damage and recovering vehicles, and while regrouping and reforming to resume forward movement. Surviving command, control and communications elements attempt to minimize the aftermath delay when regaining control of the situation. Finally, a residual degradation of rate and distance potential will occur through the loss of organic unit supplies such as POL and ammunition, and/or the means to distribute these supplies.

$$D \text{ (Delay imposed)} = I \text{ (Immediate)} + A \text{ (Aftermath)} + R \text{ (Residual)}$$

**Figure 3: Components of Total Delay**

The total delay time imposed by air attack is the sum of the component delays (see figure 3). The immediate (I) component can be computed in a relatively straightforward manner. Its value is simply the duration of the air attack. In the aftermath of air attacks, several damage control measures are conducted in parallel, as well as simultaneous efforts to regroup and resume. This is a complex problem and may depend on the nature and extent of damage and the resources available for completing the required actions. Indeed, it may not be possible to represent the aftermath and residual components of delay with models that only consider attrition. The number of remaining personnel and specialized equipment limitations may also effect the time required. Residual delays are also complex and depend on the exact nature and extent of loss, as well as the tactical situation. The specific type and quantity of remaining supplies, the ability to distribute them, the current demand for those supplies, and the capability of higher echelon units to re-supply and re-equip the unit, all effect the residual delay. Evidence of standard values for aftermath and residual delays were not found, but modeling and simulation techniques may provide estimates for their values.

Additionally, a demonstrated or perceived ability to destroy through interdiction may by itself achieve substantial delay and diversion of enemy resources, such as restricting movement to nighttime.<sup>90</sup> The Germans during WWII eventually restricted movement to nighttime operations or during periods of poor visibility to limit air power effects. The Soviets also preferred to conduct marches under concealment, whether at night or daylight conditions of limited visibility.<sup>91</sup> Indeed, the predominant Russian ground force night activity is movement. In addition, major repair and re-supply is planned for night when possible.<sup>92</sup> However, the Soviets also recognize the difficulties of

<sup>90</sup> Test Pub, Joint Pub 3-03, *Doctrine For Joint Interdiction Operations*, p. II-3.

<sup>91</sup> Reznichenko, p. 191.

<sup>92</sup> Field Manual (FM) 90-22, *Multi-Service Night and Adverse Weather Combat Operations*, US Army Training and Doctrine Command, Fort Monroe VA, 1991, p. 13.

night movement. Navigation and orientation are complicated by darkness, routine command and control problems are compounded, and effecting mutual coordination becomes more difficult.<sup>93</sup> Typical Soviet march rates for mixed columns of both tracked and wheeled vehicles are 20-30 kilometers per hour (kph) for daytime road travel, 15-20 kph for nighttime road travel, and 5-15 kph for cross country (off-road) travel.<sup>94</sup> Standard march rates for US Army units also illustrate slower speeds for nighttime operations. The standard rate is 32 kph on average roads, with the blackout rate being 16 kph.<sup>95</sup> Forcing the enemy to resort to only nighttime movement does more than just limit travel half of each 24 hour period; it also reduces the speed of travel which in turn decreases the distance the forces are able to travel at night. The potential travel distance decrease is even more dramatic if the enemy is forced to off-road travel.

### **BREAKPOINT ANALYSIS**

Field Marshal Rommel concluded from his experience in North Africa that air attacks alone could eventually render a unit unfit for combat.<sup>96</sup> A review of efforts to study historical battles to determine breakpoint measurements is somewhat mixed. The following review is by no means exhaustive. The sheer number of available studies indicates that many experts believe history can provide valuable answers. Given the complex nature of warfare, it is not surprising that several hypotheses examined did not stand up to rigorous statistical tests of the available databases. One investigator surmised that "almost every possible combination of weapons, tactics, and outcomes may be found at one time or another in the past."<sup>97</sup> Complex factors that make statistically rigorous investigation of a historical database difficult include, but are by no means limited to: leadership, morale, terrain, weather, surprise, combat experience, training, and availability of replacements and reinforcements.<sup>98</sup> Although no universal, single measure for breakpoints could be determined, useful trends have been discovered. Combinations of variables were found that were useful for predicting breakpoints.

Many studies have been done with historical battle data in an attempt to find a quantifiable measure of defeat, or success depending on the researcher's perspective. These studies generally focus on casualty totals, casualty rates or ratios, force ratios, and other quantifiable variables. They attempt to quantify breakpoints or disengagement criteria. A breakpoint is the point at which a unit is forced to change its primary mission,

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<sup>93</sup> James F. Gebhardt, Major, USA, Night Attack By A Soviet Battalion, Soviet Army Studies Office, US Army Combined Arms Center, Fort Leavenworth, KS, 1989, p. 4.

<sup>94</sup> Soviet Army Operations, p. 3-21.

<sup>95</sup> Field Manual (FM) 71-3. The Armored And Mechanized Infantry Brigade, Headquarters, Department of the Army, Washington DC, 1996, p. H-22.

<sup>96</sup> Hart, The Rommel Papers, pp. 284-285.

<sup>97</sup> Robert McQuie, Historical Characteristics of Combat For Wargames (Benchmarks), US Army Concepts Analysis Agency, Bethesda MD, 1988, p. 13.

<sup>98</sup> Dorothy Kneeland Clark, Casualties as a Measure of the Loss of Combat Effectiveness of an Infantry Battalion, Operations Research Office, The Johns Hopkins University, Chevy Chase MD, 1954, pp. 30-33.

or in other words, when it undergoes a forced posture change. When a breakpoint is reached, a change in combat posture occurs. The breakpoint represents the state at which a unit is no longer able to perform its primary assigned mission and therefore must change missions. In other words, the breakpoint represents the state at which a unit has lost its combat effectiveness for the assigned mission.<sup>99</sup>

Reportedly, Army officers generally claim ground units lose combat effectiveness when suffering between 20 and 30 percent casualties.<sup>100</sup> In fact, many wargames and simulations portray casualties in the 15-30% range. Indeed, one study found these high casualty rates inconsistent with an analysis of historical battles. Trevor Dupuy found that historically most division size forces quit before casualties reached 10% per battle or about 3% per day.<sup>101</sup> However, some objective may be so important that higher casualty rates are acceptable. When issuing orders once to the 1st Armored Division to attack even if they sustained losses of 25 %, General George S. Patton wrote, "I feel quite brutal in issuing orders to take such losses, especially when I personally am safe, but it must be done."<sup>102</sup> Another study conducted by the Operations Research Office of the John Hopkins University concluded the use of specific casualty values alone to determine combat effectiveness is a gross oversimplification. Among other determining variables identified, the report concludes that the type and size of the unit, replacement availability, and the particular unit mission must be considered. Differing ranges of loss percentages were associated with breakpoints from attack to defense and defense to withdraw. For example, breakpoints from attack to defense were found to occur at casualty rates of 4 to 23 percent in the first few days with no replacements. While breakpoints from defense to withdraw for second week battles was found to occur at cumulative casualty rates of 42 to 71 percent enlisted men and 29 to 63 percent officers.<sup>103</sup>

The Combat History Analysis Study Effort (CHASE) was conducted to search for historically-based quantitative results for use in military operations research, concept formulation, wargaming, and studies and analyses.<sup>104</sup> This historical database was then used to test a breakpoint hypothesis. It was hypothesized that battle termination was governed by a casualty fraction value (breakpoint) chosen from a distribution of casualty-fractions (break curves). It was further hypothesized that the break curves are the same for all battles, irrespective of the size of forces involved or when, where, by whom, or with what the battle was fought. The final part of the hypothesis was that losses, and hence equivalently the casualty fractions, of the forces are deterministically and

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<sup>99</sup> Clark, p. 8.

<sup>100</sup> Clark, p. 7.

<sup>101</sup> Trevor N. Dupuy, Understanding Defeat. How to recover from Loss in Battle to Gain Victory in War, Paragon House, New York, 1990, p. 218.

<sup>102</sup> D'Este, p. 476.

<sup>103</sup> Clark, p.35.

<sup>104</sup> Robert L. Hembold and Aqeel A Khan, Combat History Analysis Study Effort (CHASE). Progress Report For the Period August 1984-June 1985, US Army Concepts Analysis Agency, Bethesda MD, 1986, p. V.



monotonically related to each other.<sup>105</sup> Statistical tests on the historical database showed that at least one of the three postulates of the hypothesis must be wrong.<sup>106</sup>

The results of this statistical test should not be surprising considering the attempt to make the hypothesis all-encompassing with regard to where, whom, and with what the battle was fought. In addition, the hypothesis to determine breakpoints did not account for the size of the forces involved. Generally, the casualty rate is inversely proportional to the size of the unit. In other words, one would expect larger units to have lower casualty rates than their smaller component units.<sup>107</sup> First, smaller component units have fewer supporting individuals who do not directly engage in combat, than do the larger units. A larger portion of the small units engage in combat and are therefore exposed to fire. Second, as force size increases, the number of human interactions required to communicate situations and orders also increases. This "Clausewitzian" friction causes delays in the performance of missions and therefore troops are exposed to hostile fire less promptly.<sup>108</sup> Additionally, the duration over which the attrition is calculated and the level of combat may be influential.<sup>109</sup> Statistics from long battles with many replacements may show larger units to have suffered a higher casualty rate than smaller or shorter battles.

A subsequent study conducted for the US Army's Concept Analysis Agency reviewed literature analyzing the relationship of casualties to breakpoints.<sup>110</sup> The study initially hypothesized that casualties appeared to be neither a necessary nor a sufficient condition for a posture change. That did not mean that casualties did not matter, but the level at which they mattered varied according to the circumstances of the battle. Along with other factors, if commanders had pre-decided upon a casualty based breakpoint, then difficulties with timely assessment of casualties and the relay of orders may contribute to engagements continuing beyond that pre-determined breakpoint.<sup>111</sup> Finally, the study concluded that tactics and enemy maneuver, relative combat strength and combat losses were the critical variables.<sup>112</sup>

The study produced a breakpoint model for the purpose of determining combat termination in simulations and wargames (See figure 4.). Both time-step and event versions were produced, with the time-step version of the model having the best success in reproducing historical battle results. Among other conditions the time-step version of

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<sup>105</sup> Hembold and Khan, pp. 6-8.

<sup>106</sup> Hembold and Khan, p. 6-12.

<sup>107</sup> Dupuy, *Attrition* p. 10.

<sup>108</sup> Dupuy, *Attrition*, p. 42.

<sup>109</sup> Dupuy, *Attrition*, p. 10.

<sup>110</sup> Janice B. Fain, Richard C. Anderson, Trevor N. Dupuy, Gay M. Hammerman, and Charles F. Hawkins, *Forced Changes of Combat Postures*, Historical Evaluation and Research Organization, Fairfax VA, 1988, p. IV-2.

<sup>111</sup> Fain, et al., p. VII-3.

<sup>112</sup> Fain, et al., p. VII-4.

<sup>112</sup> Fain, et al., p. VI 16-18.

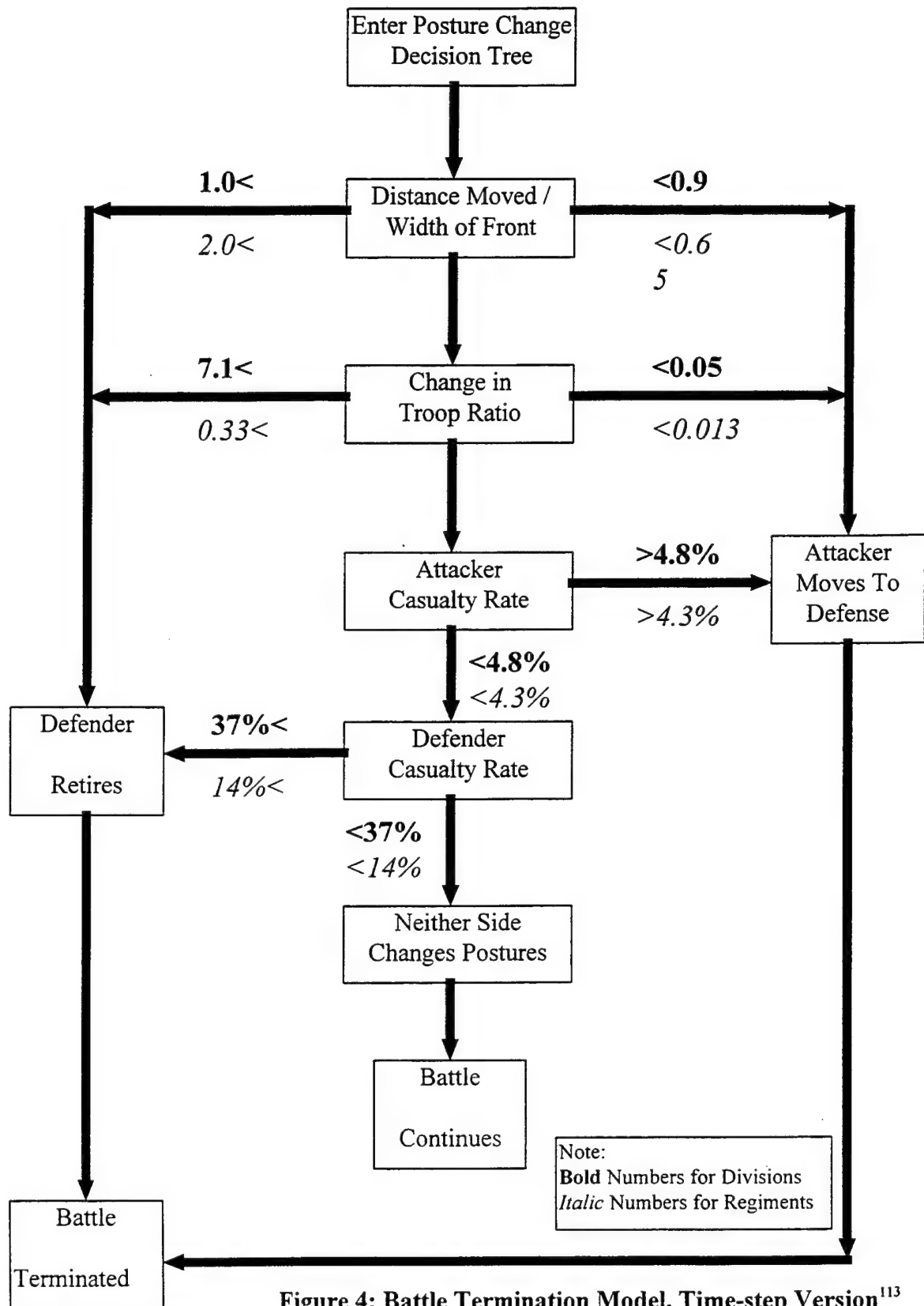


Figure 4: Battle Termination Model, Time-step Version<sup>113</sup>

<sup>113</sup> Fain, et al, p. VI 16-18.



the model uses attacker casualties of greater than 4.8%, and defender casualties of greater than 37% as breakpoints at the division level. At the regiment level the breakpoints were found to occur at casualties greater than 4.3% for the attacker and greater than 14% for the defender.<sup>114</sup>

A recent study explored the interrelationship between entropy and breakpoints, or chaos of command and control processes and casualties. Casualty infliction was believed to reduce the structural cohesion of a force, which caused the kind of disorder that leads to collapse on the battlefield. The study found that system disorder, or entropy, reaches a maximum when the casualty rate reaches 37%. The study also concluded a unit with 20-30% casualties has "endured very heavy casualties indeed."<sup>115</sup> Therefore, the 37% maximum should point to a breakpoint or forced posture change. Once again, the theory was tested against historical WWII databases. Time-normalized casualty based entropy predictions correctly matched 46 of 59 examined historical battle outcomes. Similar results were found when testing Korean War battles and National Training Center exercise results.<sup>116</sup>

## **MATERIEL ATTRITION**

Materiel or equipment attrition has not been specifically analyzed in the studies discussed so far. Indeed, the data used in most studies came predominantly from infantry units. With the increasing importance of equipment and weapon systems such as artillery, trucks and tanks, came an increasing effort to directly target the opposing force's equipment and weapon systems. Since personnel operate the equipment and weapon systems, there should be some relation between materiel losses and personnel casualties.<sup>117</sup> Regardless of any relationship between materiel losses and personnel casualties suffered because personnel occupy combat vehicles, it seems intuitive that the combat effectiveness of a modern armored or mechanized forces should be related to the amount of weapon systems they can employ. In other words, combat effectiveness degradation should be related to the attrition of a unit's primary entity. Just as the foot soldier is the primary combat entity for infantry units, the primary combat entities for armored or mechanized units are tanks and infantry fighting vehicles. Therefore, it should be possible to relate breakpoints to the attrition of these primary weapon systems. Of course adequate supplies, especially POL, ammunition and food, and the means to distribute these supplies, are absolutely critical for these primary weapon systems to remain mobile and effective.

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<sup>115</sup> John T. Dockery and A.E.R. Woodcock, The Military Landscape. Mathematical Models of Combat, Woodhead Publishing Limited, Cambridge, England, 1993, pp. 195-197.

<sup>116</sup> Dockery and Woodcock, pp. 206-209.

<sup>117</sup> Trevor N. Dupuy, Understanding War. History and Theory of Combat, Paragon House Publishers, New York, 1987, p.178.

Noted military historian Trevor Dupuy led a study for the US Army Training and Doctrine Command to analyze the relationship between casualties and tank loss rate. The study found a distinct pattern with respect to the ratio of the tank loss rate to the casualty rate when examining the loss rates of the US, British, Soviets and Germans in WWII, and the 1973 Arab-Israeli War. The ratio of tank loss rates to casualty rates was found to remain relatively constant as the proportion of tanks increases above six per 1000 troops. The average armor loss ratio values were determined to be six for offensive units and three for defensive units.<sup>118</sup> Although the ratios were derived in order to predict casualties, perhaps they might also be useful in predicting breakpoint conditions. These ratios might be used to translate historical casualty rate based breakpoints into attrition based breakpoints more relevant to modern warfare.

Applying these ratios to the previously discussed casualty breakpoints for the CAA event version model produces interesting results (see figure 5). With the obvious exception of defender tank losses, the resulting tank loss rates for breakpoints appear to be reasonable. The defending infantry divisions in the data base may have been able, or simply willing, to endure higher personnel attrition in relation to the attrition an armored division could accept. Since the casualty breakpoints were derived from historical battles and campaigns, replacements would no doubt have been received over the duration of the battles or campaigns. Perhaps beleaguered defenders in the studied battles received disproportionate amounts of replacements during critical battles. Replacement and reconstitution may invalidate historical casualty-derived attrition breakpoint analyses of short duration battles.

<b>Breakpoints</b>				
	Unit Size	Casualties	Ratio	Tank Loss
Attacker	Regiment	4.3%	6	25.8%
Attacker	Division	4.8%	6	28.8%
Defender	Regiment	14.0%	3	42.0%
Defender	Division	37.0%	3	111.0%

**Figure 5: Hypothetical Attrition Based Breakpoints Derived From Casualty Data**

Recent experience in Operation DESERT STORM provides an example of the use of equipment and weapon system attrition. In fact this use of attrition levels appears to have set a precedent for their use, and misuse, in current analyses. General H. Norman Schwarzkopf explained that units are generally considered combat ineffective when they reach 70% remaining combat strength (30% attrition), and at 50% they would be "really combat ineffective."<sup>119</sup> Perhaps more precisely, the 50% attrition goal was required to make the force ratios more favorable for a coalition attack. The Iraqi forces were

<sup>118</sup> Trevor N. Dupuy, The Effects of Combat Losses And Fatigue On Operational Performance, Historical Evaluation and Research Organization, VA, 1979, p. 54 .

<sup>119</sup> Eric Reinert, President George Bush: Lessons of Leadership, Achievement Television Network, 1995, interview of General H. Norman Schwarzkopf.

assessed to outnumber coalition forces by at least 3-to-2. Among other things, an attacker to defender ratio of 3-to-1 is generally desirable for attack, and a favorable ratio of 5-to-1 is generally desired to attack heavily dug in and barricaded troops such as the Iraqi troops along the border in Kuwait.<sup>120</sup> During the "Mother of All Briefings," General Schwarzkopf explained how the air campaign "was necessary to reduce these forces down to a strength that made them weaker, particularly along the front line barrier that we had to go through."<sup>121</sup> Not only did the air campaign attrit the Iraqi forces, but it isolated the theater and prevented the Iraqis from replacing, reinforcing, repairing, or even re-supplying their forces in Kuwait which could have tipped the ratio balance back towards their favor.<sup>122</sup>

Indeed, air attacks made the task of breaching coalition units easier, for when they attacked straight ahead into Iraqi positions, they found enemy units less than 50 percent effective.<sup>123</sup> Perhaps General Schwarzkopf's attrition requirements for combat ineffectiveness could be stated more precisely. Requiring attrition of 30% would make an unit combat ineffective for an offensive mission, and requiring attrition of 50% would make an unit combat ineffective for a defensive mission. His ultimate goal was to make the Iraqi units defensively combat ineffective prior to the Coalition's ground campaign. Hence the 50% attrition goal was set. Therefore, it may be an over statement to cite the DESERT STORM 50% attrition requirement as the precedent basis for requiring 50% attrition in order to halt attacking forces.

## **DOCTRINAL ANALYSIS**

Some countries make extensive use of quantified variables and equations to solve military problems. "Norms" were vitally important to the Soviet military. The Soviet military defined norms as "operational-tactical numerical quantities used to characterize space and time factors for operational or tactical activities of forces and the areas in which they take place." Norms are established by either experience, analytical calculations or statistical methods. They are used to determine how fast or far a Soviet army unit can move, how many artillery rounds are required to destroy a target, how many tanks are required per kilometer, etc. Obviously, many of these military norms are classified and not generally available.<sup>124</sup> Soviet artillery calculations for projectile expenditure rates provide some insights on breakpoints. Entering assumptions for

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<sup>120</sup> John Pimlott, Stephen Badsey and members of the Department of War Studies Royal Military Academy, Sandhurst, The Gulf War Assessed, Arms and Armor Press, 1992, p. 149.

<sup>121</sup> Charles D. Melson, U.S. Marines in the Persian Gulf, 1990-1991: Anthology and Annotated Bibliography, Headquarters, US Marine Corps, Washington DC, 1992, pp. 49.

<sup>122</sup> Melson, pp 49-51.

<sup>123</sup> Frank N. Schubert and Theresa L. Kraus, The Whirlwind War, The United States Army in Operations DESERT SHIELD and DESERT STORM, Center of Military History, United States Army, Washington DC, 1995, p. 205.

<sup>124</sup> John Erickson, Lynn Hansen and William Schneider, Op. Cit., Soviet Ground Forces. An Operational Assessment, Westview Press, Inc., Boulder CO, 1986, pp. 141-142.

artillery calculations require a 30% level of destruction to suppress a target, and a 50-60% level of destruction is required to annihilate or destroy a target.<sup>125</sup> Assumptions are based on wartime experience and years of studies and tests.<sup>126</sup> To "suppress" may be defined as to "restrain from a usual course of action."<sup>127</sup> In a military application, suppression temporarily removes the enemy's ability to fight and inhibits his ability to maneuver.<sup>128</sup> This indicates that a unit suffering 30% destruction would be considered by the Soviets to be unable to fight or maneuver. Such an attrited unit could be considered combat ineffective, and therefore at its breakpoint for offensive missions.

A 1975 work on military forecasting also illustrates Soviet thought on breakpoints. A battalion was considered to be capable of carrying out any combat mission if its strength is between 65 and 100%. It loses the ability to attack below 65%, and if there are no reinforcements, it can carry out a defensive mission down to 50%. Below 50% the battalion's capability is reduced to only being able to conduct a fighting delay action.<sup>129</sup> Lieutenant Colonel Yuri Demerenko, previous Commander of the 135th Guards Motorized Rifle Regiment, Commonwealth of Independent States, explained current Russian thought during a 1993 interview. Attacking units at the Brigade level and below are considered to be combat ineffective for an attack if only 50% of its primary fighting systems remain and it is not within direct range of its objective. They would be combat ineffective at 40% remaining for a prepared defense, and they would be combat ineffective at 50% remaining for a hasty defense. He stated that at the division level a unit becomes combat ineffective at 65% remaining combat power for either attack or defense. For example, even if component brigades (and battalions) are combat effective, the overall division would be considered combat ineffective if it was under 65% combat power overall. This update to Soviet thought is due to the higher level of complexity associated with combined arms operations at the division level, and modern sustainment requirements for heavy armored and mechanized units.<sup>130</sup>

US Army Field Artillery employment also makes use of mathematically specified levels of damage. Neutralization temporarily knocks the targeted unit out of action and occurs when 10% or more casualties or damage is inflicted.<sup>131</sup> When the casualties are

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<sup>125</sup> Chris Bellamy, Red God of War, Soviet Artillery and Rocket Forces, Brassey's Defence Publishers, London, 1986, p.177.

<sup>126</sup> David C. Isby, Weapons and Tactics of the Soviet Army, Jane's, London, 1981, p.169.

<sup>127</sup> Webster's Ninth New Collegiate Dictionary, Merriam-Webster Incorporated, Springfield Massachusetts, 1985, pp. 795 and 1186.

<sup>128</sup> Gary J. McCarty, Norms and the Red God of War -- Gospel for the King of Battle, School of Advanced Military Studies, United States Army Command and General Staff College, Fort Leavenworth KS, 1990, p. 7.

<sup>129</sup> Yu. V. Chuyev, Yu. B. Mikhavlov, Forecasting in Military Affairs, Moscow, Translated by the DGIS Multilingual Section, Translation Bureau, Secretary of State Department, Ottawa, Canada, 1975, pp. 86-88.

<sup>130</sup> Yuri Demerenko, Lt Col., Commonwealth of Independent States, interview conducted by Cyrus Holliday, 1993, at Fort Leavenworth, KS.

<sup>131</sup> Field Manual (FM) 6-20-20, Tactics, Techniques and Procedures for Fire Support at Battalion Task Force and Below, Headquarters, Department of the Army, Washington DC, 1991, p. 1-2.

replaced and the damage repaired, the unit becomes effective again.<sup>132</sup> Destruction puts a target permanently out of action and occurs when 30% casualties or materiel damage is inflicted during a short time span.<sup>133</sup> In other words, destruction renders a unit combat ineffective.<sup>134</sup> Achieving this level of destruction requires large expenditures of ammunition, and is therefore not considered economical.<sup>135</sup> Field artillery, tactical aircraft, mortars, and even naval gunfire may provide the fires to achieve the desired level of damage.<sup>136</sup>

Field Manual 6-20-10, Tactics, Techniques, and Procedures for The Targeting Process cautions that simple attainment of this level of destruction does not guarantee achievement of the commander's intent, as the surviving 70% may still influence the operation.<sup>137</sup> This US Army artillery specified level for destruction (30%) is far less than the previously discussed Soviet specification (50-60%). However, US Army maneuver units use 70% as their criteria for destruction which is closer to the Soviet criteria.<sup>138</sup> If the commander's intent is simply to render the enemy unit incapable of offensive actions, then 30% may be adequate. However, when the commander's intent is to attack, overrun and defeat, then the remaining 70% will certainly influence the operation. The difference in US Army artillery and maneuver unit criteria may also be due to engagement techniques. Maneuver forces tend to directly engage individual pieces of equipment such as tanks, armored fighting vehicles, and artillery, whereas artillery forces generally engage area targets. When achieving 30% destruction with artillery, much more additional ancillary damage is inflicted as well as effecting morale. Air attacks with "dumb" or unguided munitions would also produce additional ancillary damage. Moreover, a truly precise measurement of combat effectiveness cannot be made by a simple tally of destroyed tanks and armored fighting vehicles.<sup>139</sup> The final determination on target destruction must depend upon actual achieved effects. Nonetheless, the 30% destruction criteria provides a quantifiable goal.

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<sup>132</sup> Field Manual (FM) 6-30, Tactics, Techniques and Procedures for Observed Fire, Headquarters, Department of the Army, Washington DC, 1991, p. E4,5.

<sup>133</sup> Field Manual (FM) 6-71, Tactics, Techniques, and Procedures For Fire Support For The Combined Arms Commander, Headquarters, Department of the Army, Washington DC, 1994, p. 3-5.

<sup>134</sup> Field Manual (FM) 6-30, Tactics, Techniques and Procedures for Observed Fire, p. 4-9.

<sup>135</sup> Field Manual (FM) 6-20-20, Tactics, Techniques and Procedures for Fire Support at Battalion Task Force and Below, p. 1-2

<sup>136</sup> Field Manual (FM) 6-20-20, Tactics, Techniques and Procedures for Fire Support at Battalion Task Force and Below, p. 2-1.

<sup>137</sup> Field Manual (FM) 6-20-10, Tactics, Techniques and Procedures for The Targeting Process, Headquarters, Department of the Army, Washington DC, 1996, p. 2-8.

<sup>138</sup> Field Manual (FM) 6-20-10, Tactics, Techniques and Procedures for The Targeting Process, p. 1-2.

<sup>139</sup> Field Manual (FM) 6-71, Tactics, Techniques, and Procedures For Fire Support For The Combined Arms Commander, p. 3-6.

## QUANTIFYING HALT CRITERIA

Using the Operation DESERT STORM 50% attrition precedent as the criteria for determining the halt of advancing forces is inappropriate. That number was established to solve quite a different problem involving force ratios and non-advancing forces in defensive postures. Theory points to a breakpoint at 37% attrition of combat strength for the attacker. Soviet style doctrine points to a breakpoint at 35% attrition of combat equipment at the division level, while US Army field artillery definitions set the combat ineffective level at 30% attrition. Historical evidence points to a breakpoint level less than 30% attrition for the attacker. Therefore, it seems reasonable to set the attrition level required to halt advancing forces at the 35% attrition level.

## CONCLUSION

*Because of hostile domination of the air, travel anywhere in the forward area was an exciting business. Lookouts kept a keen watch of the skies and the appearance of any plane was the signal to dismount and scatter. Occasionally, of course, the plane would turn out to be friendly -- but no one could afford to keep pushing ahead on the chance that this would be so. All of us became quite expert in identifying planes, but I never saw anyone so certain of distant identification that he was ready to stake his chances on it. Truck drivers, engineers, artillerymen, and even the infantrymen in the forward areas had constantly to be watchful. Their dislike of the situation was reflected in the constant complaint, "Where is this bloody Air Force of ours? Why do we see nothing but Heinies?" When the enemy has air superiority the ground forces never hesitate to curse the "aviators." General Dwight D. Eisenhower, Supreme Allied Commander<sup>140</sup>*

Historically, focused air interdiction has provided a powerful tool to attrit and delay enemy forces. Early allied experience in North Africa demonstrated the impact of air interdiction. After the allies gained air superiority, they employed air interdiction to destroy enemy forces and supplies, and constrain movement. A review of current doctrine and tactics of the US and Russian Armies reveals extensive measures designed to stop air attacks and limit the impacts of those that cannot be stopped. The total delay in movement imposed by air attack sum of the immediate, aftermath and residual delays. Upon suffering a certain level of damage, advancing ground units should be rendered mission ineffective, and will then stop advancing. Historical evidence suggests that the level of damage required to halt advancing forces is at 30% destruction of the unit's primary combat entities. Doctrinally, Soviet style divisions consider themselves combat ineffective when below 65% strength remaining.

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<sup>140</sup> Eisenhower, p. 120.

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## ACRONYMS

<i>A</i>	<i>Aftermath Delay</i>
A.A.	Anti Aircraft [Artillery]
ADA	Air Defense Artillery
AFM	Air Force Manual
ARTEP	Army Training and Evaluation Program
CAA	Concepts Analyses Agency
CHASE	Combat History Analysis Study Effort
<i>D</i>	<i>Total Delay Imposed</i>
FKSM	Fort Know Supplemental Material
FM	Field Manual
<i>I</i>	<i>Immediate Delay</i>
JFACC	Joint Forces Air Component Commander
kph	kilometers per hour
METT-T	Mission, Enemy, Troops, Terrain and weather
M&S	Modeling and Simulation
NATO	North Atlantic Treaty Organization
POL	Petroleum, Oil and Lubricants
<i>R</i>	<i>Residual Delay</i>
SOP	Standard Operating Procedures
TRADOC	Training and Doctrine Command
TTP	Tactics, Techniques and Procedures
US	United States
WWII	World War II



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